Water-based Condensation Particle Counters Comparison Near a Major Freeway with Significant Heavy-Duty Diesel Traffic

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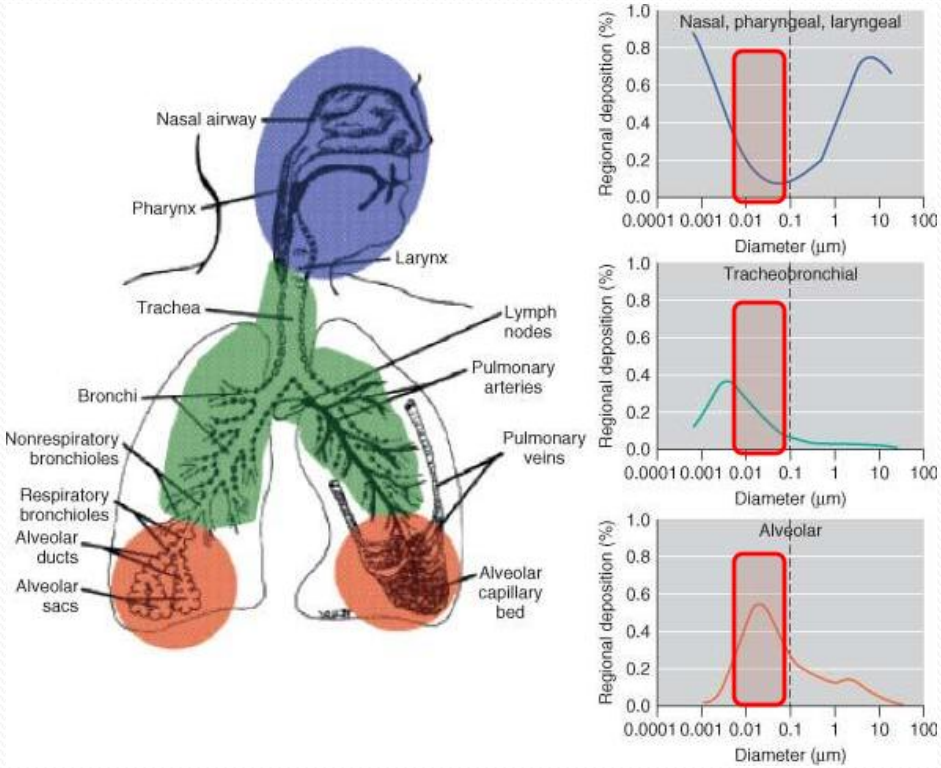
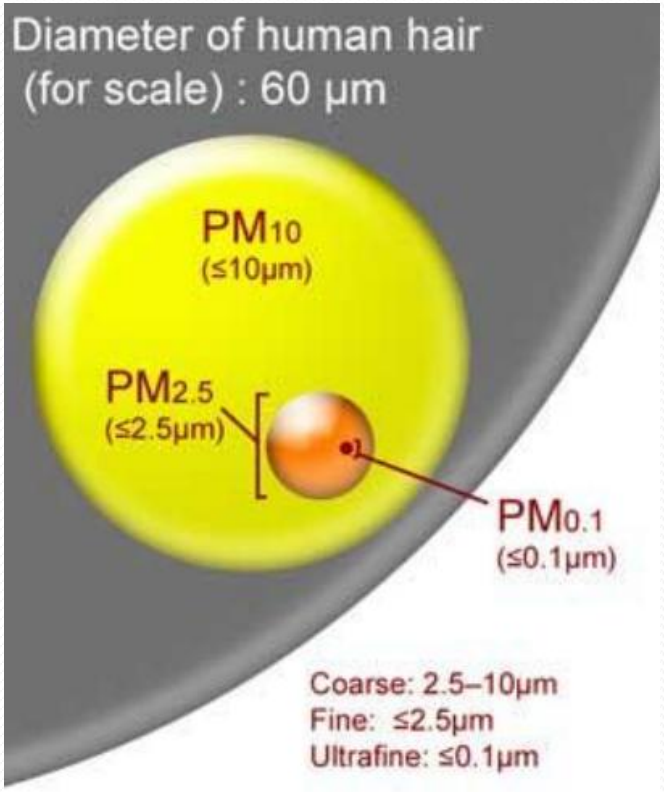
Ultrafine Particles



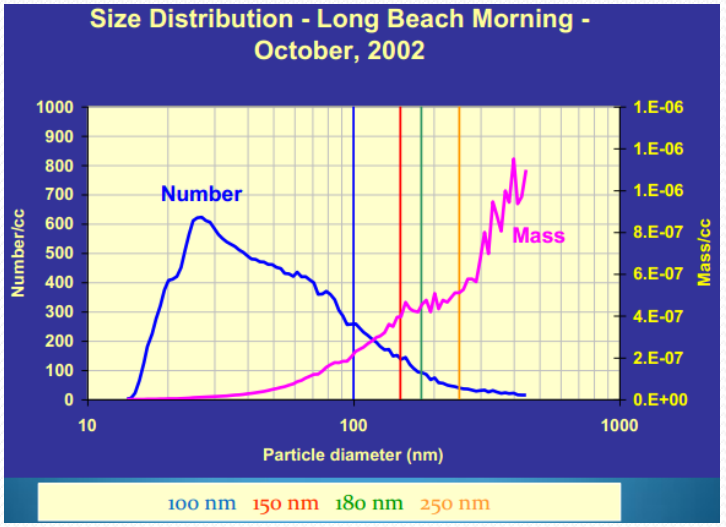


- More toxic than $PM_{2.5}$
- Can cross cell membranes and move into the circulatory system, brain, and other organs
- Adverse health effects (e.g. stroke, systemic inflammation, and asthma exacerbation)
- Suspected as one of the causative pollutants in near-traffic epidemiology studies

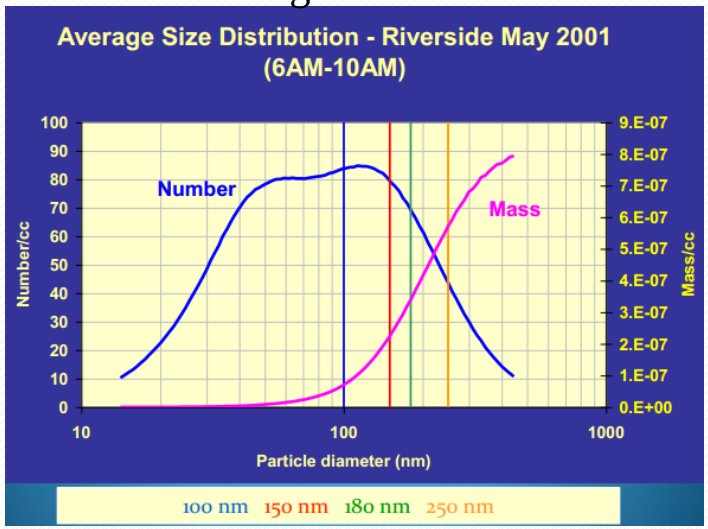
Measurement Issues

- Counting Particles
  - Full/Partial Size Distributions
    - Semi-continuous (some) but expensive
  - Total Particle
    - "Easy" continuous measurements with CPCs
    - Lower size varies with CPC type/model
    - Upper size cut selection
    - Water- vs. Butanol-CPCs
    - Potential composition effects
    - Single counting vs. photometric modes
    - Volatile vs. non-volatile particles
- UFP characteristics measured by any ambient monitoring program should reflect the latest health effects data

Fresh Aerosol

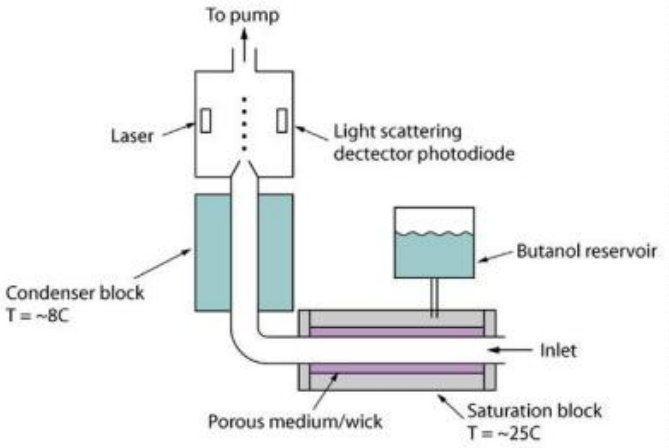


Aged Aerosol



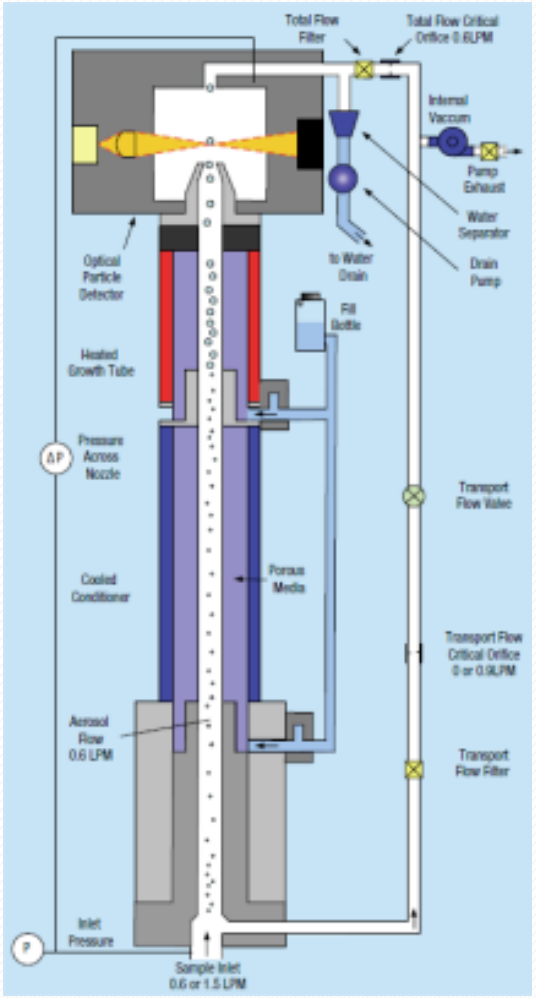
Measurement Techniques

- Condensation Particle Counters (CPCs)($12K-$30K)
  - Particle number only



- Scanning Mobility Particle Sizers (up to $70K)
  - Full size distributions
  - Number and mass (w/ assumptions)
  - Semi-continuous

- Others
  - Fast Mobility Particle Sizer (up to $120K)
  - Filter-based techniques with inlet ($5K-$25K)



Condensation Particle Counters

Table 1: CPC Specification Comparison

	8525	3007	3783	3772	3787	3775	3790	3776	3788
Specifications									
D_{50} Min. Size (nm)	20	10	7	10	5	4	20	2.5	2.5
Max. Concentration (particles/cm^3)	500,000	100,000	1,000,000	10,000	250,000	50,000 $<10^7$*	10,000	300,000	400,000
Concentration Accuracy (%)	N/A	±20	±10	±10	±10	±10 ±20*	±10	±10	±10
Response - T95 (s)	~3	<~3	<3	~3	~0.7	~4	~3	~0.8	~0.25
Sample Flow (LPM)	0.1	0.1	0.12	1.0	0.6	0.3	1.0	0.05	0.3
Total Inlet Flow	0.7	0.7	0.6/1.5	1.0	0.6/1.5	0.3/1.5	1.0	0.3/1.5	0.6/1.5
Flow Source	Internal	Internal	External	External	Internal	Internal	External	Internal	Internal
Working Fluid	Isopropanol	Isopropanol	Water	Butanol	Water	Butanol	Butanol	Butanol	Water
Weight	1.7 kg (3.8 lbs)	1.7 kg (3.8 lbs)	9.9 kg (22 lbs)	5.5 kg (12 lbs)	8.2 kg (18 lbs)	9.9 kg (22 lbs)	5.5 kg (12 lbs)	9.9 kg (22 lbs)	8.2 kg (18 lbs)
Display	Digital LCD	Digital LCD	Touch w/graph	Digital LCD	Touch w/graph	LCD w/graph	Digital LCD	LCD w/graph	Touch w/graph
Data Logging/ Storage	On-board	On-board	Flash drive	N/A	Flash drive	Memory Card	N/A	Memory Card	Flash drive
SMPS Compatibility	No	No	No	Yes	Yes	Yes	No	Yes	Yes
Price	$	$	$$	$$	$$	$$$	$$$$	$$$$	$$$$

Condensation Particle Counters

CPC Comparison Study

MOTIVATIONS

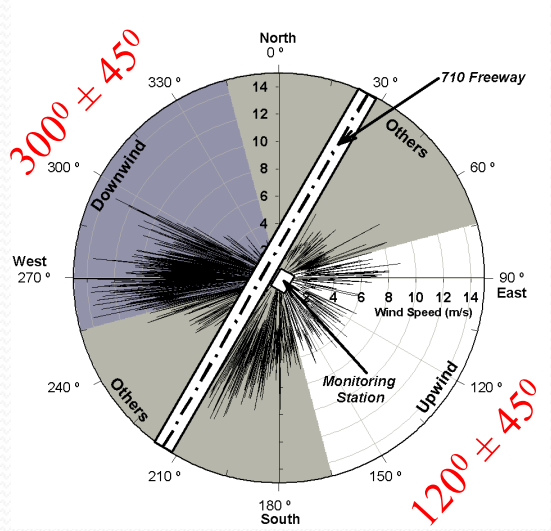
- Little information regarding response differences among different W-CPC models

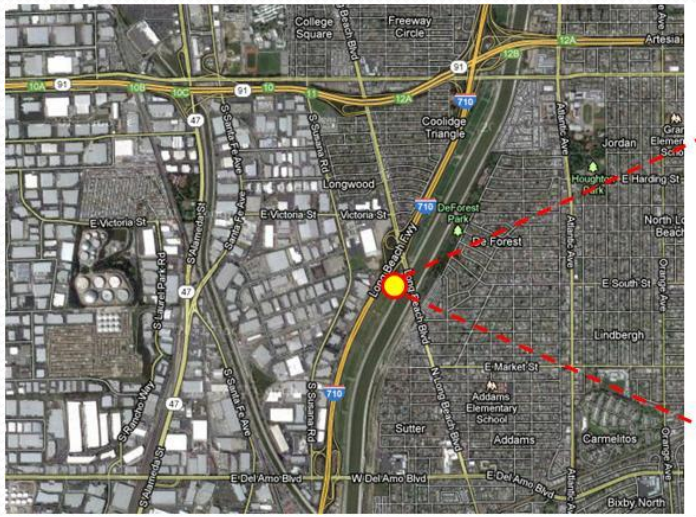
OBJECTIVES

- Evaluate TSI 3783 model performance (promoted as suitable for network operation)
- Compare with other TSI W-CPC models

METHODS

- TSI models 3781, 3783, and 3785 (three units per model) run side-by-side 15m East of the I-710 (high HDDT volume) from May 16th to June 15th, 2011
- Size distribution (SMPSs) and meteo data

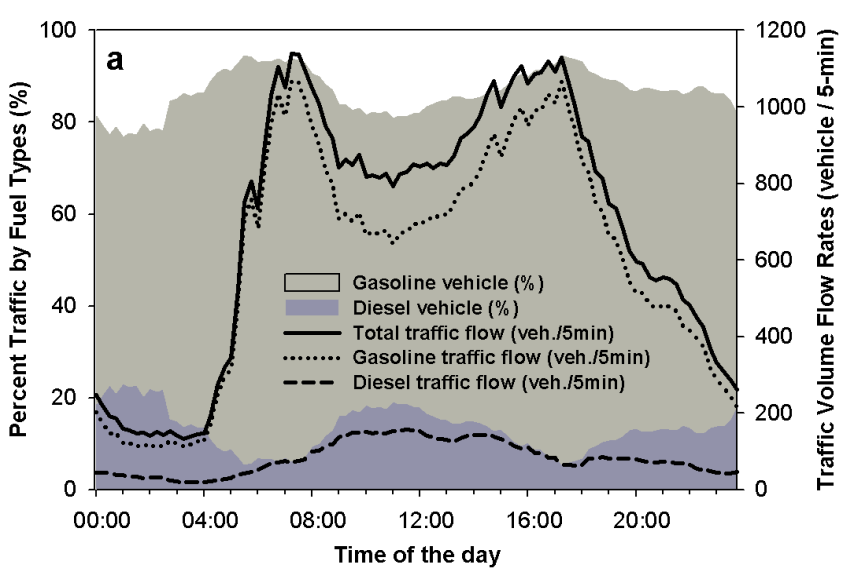


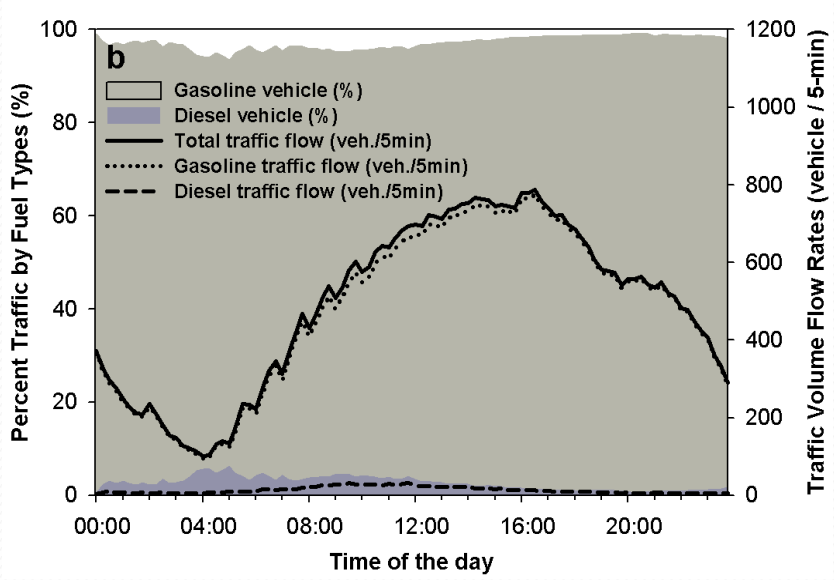


CPC Comparison Study

Specifications	Model 3781	Model 3783	Model 3785
Detectable Particle Diameter Ranges	6 nm to 3 μm	7 nm to 3 μm	5 nm to 3 μm
Time Resolution	1 min	1 min	1 min
Maximum Detectable Particle Concentrations (cm^{-3})	5×10^5	1×10^6	1×10^7
Particle Counting Errors	± 10 % at 5×10^5 cm^{-3}	± 10 % at 1×10^6 cm^{-3}	± 10 % at 2×10^4 cm^{-3}
Aerosol Flow Rates (L/min)	0.12 ± 0.012	0.12 ± 0.012	1.0 ± 0.1
Inlet Flow Rates (L/min)	0.6 ± 0.12	3 ± 0.3	1.035

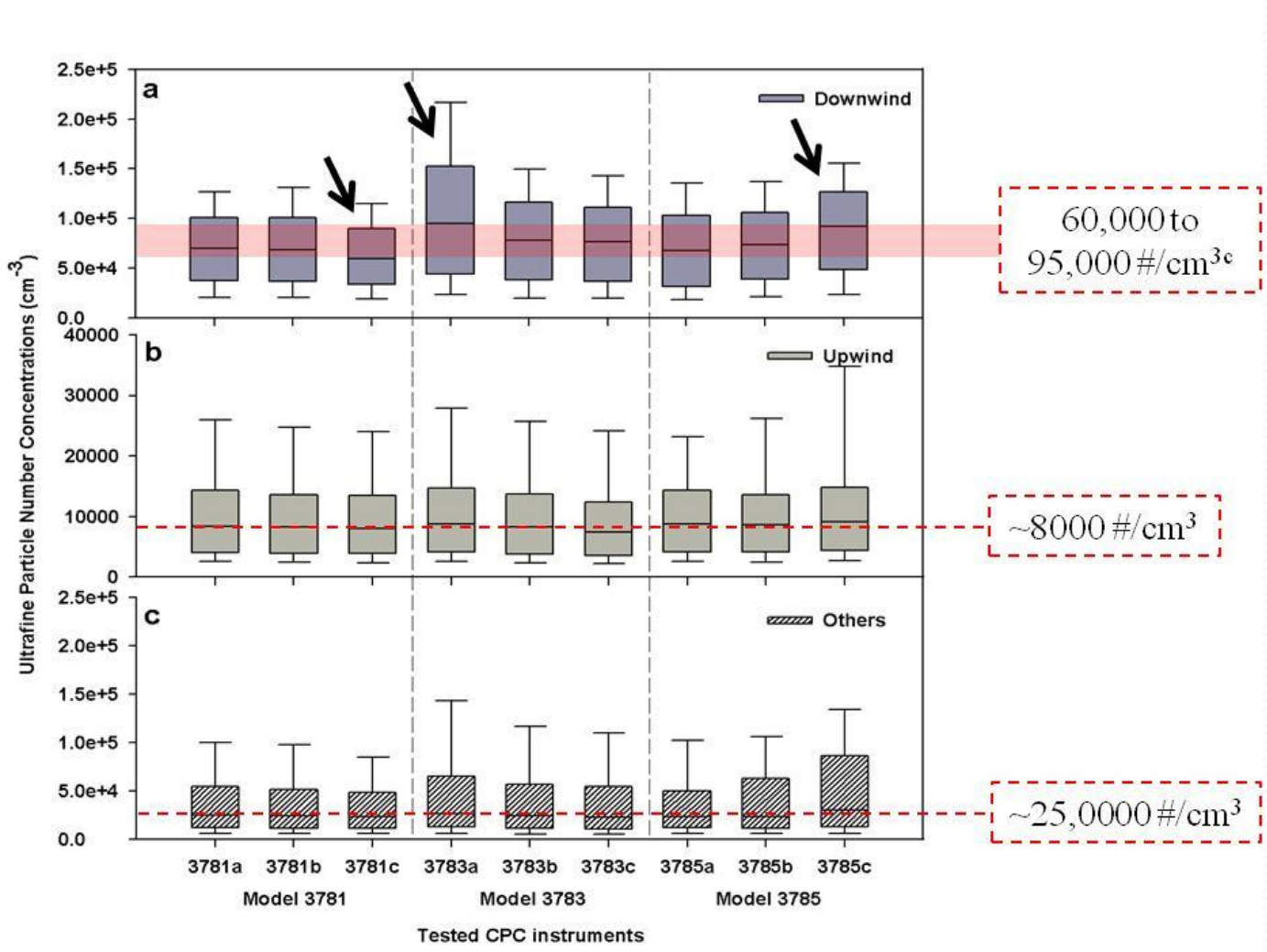
I-710 Traffic Information



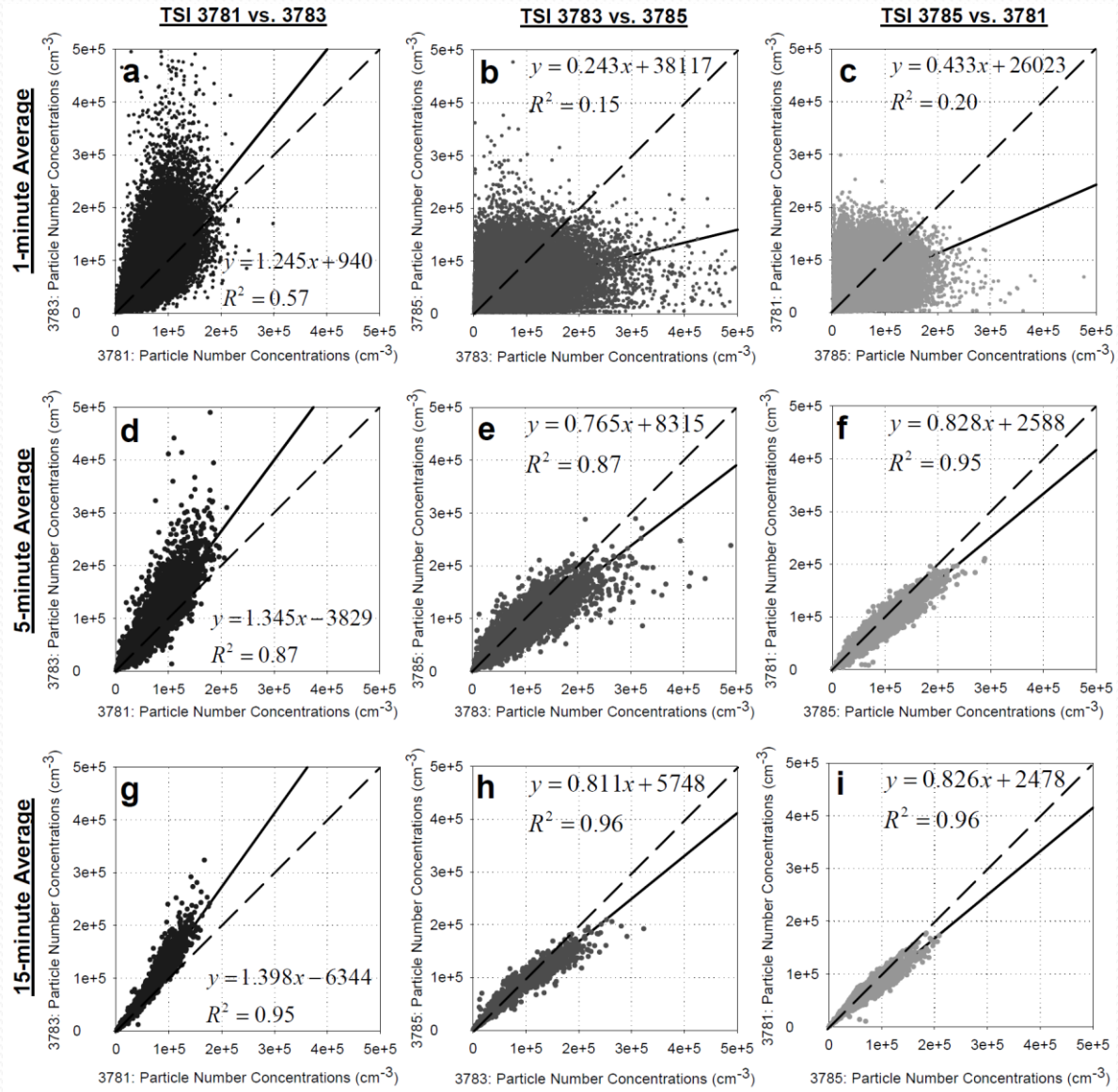


- CalTrans Performance Measurement System (PeMS): Gasoline vs. HDDV (18% of total traffic)
- Morning/afternoon rush hours: up to 1200 vehicles per 5 min
- Nighttime: 150 vehicles per 5 min
- Challenging environment: high UFP and BC concentrations

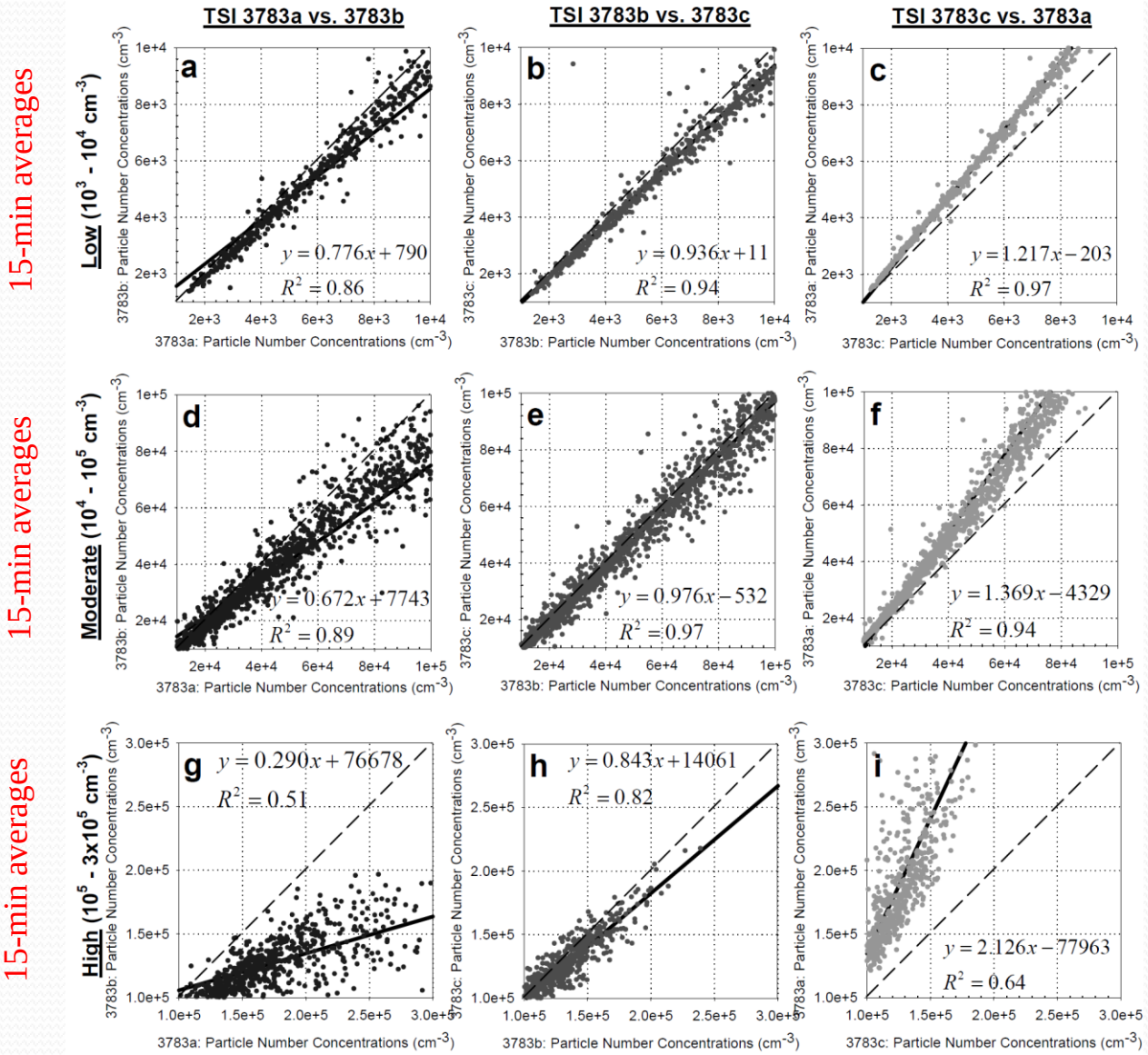
CPC Comparison - Wind Direction



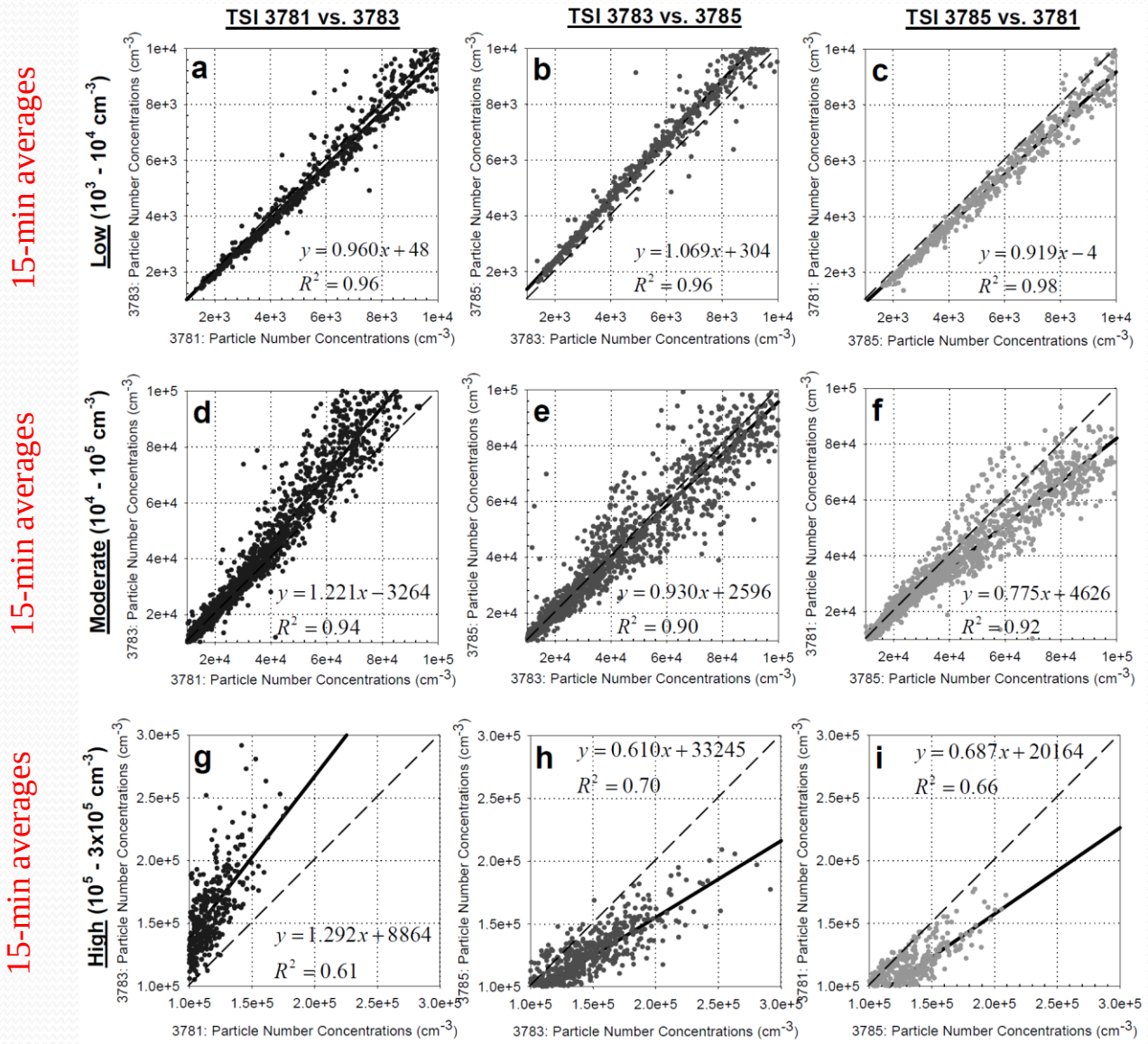
Effect of Averaging Time



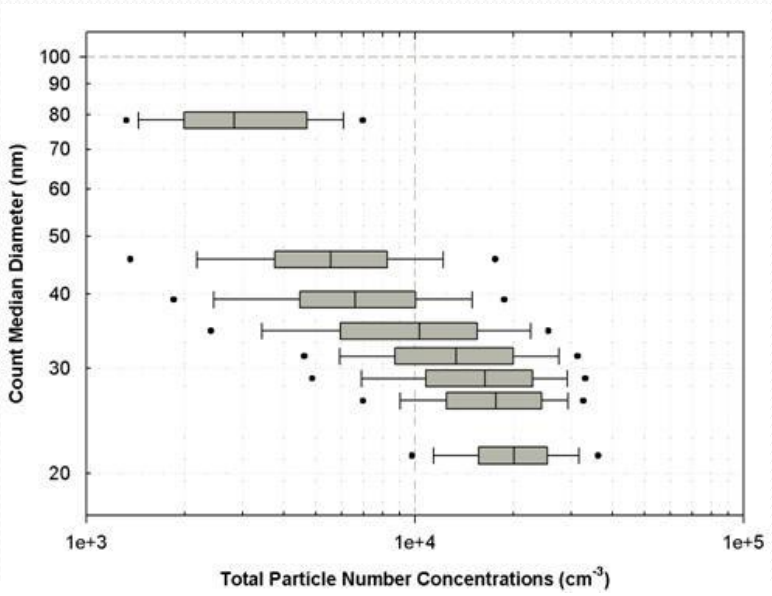
Intra-model Correlations (Precision)

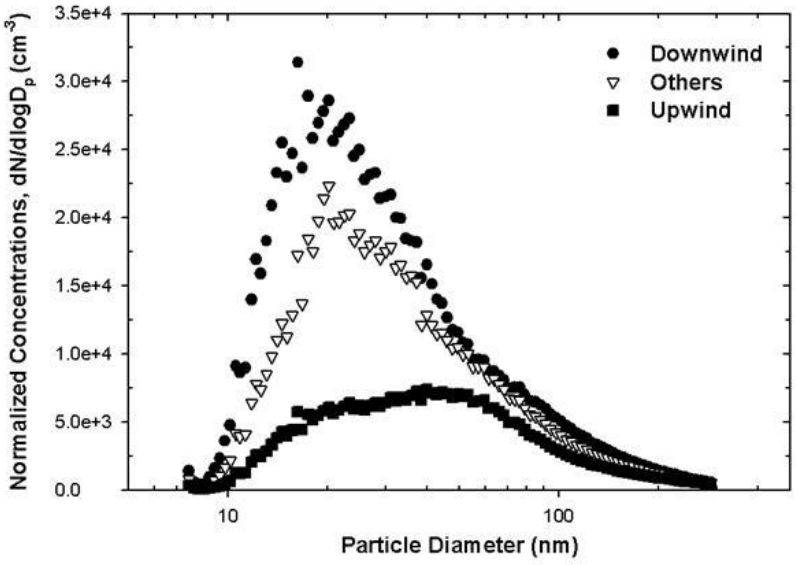


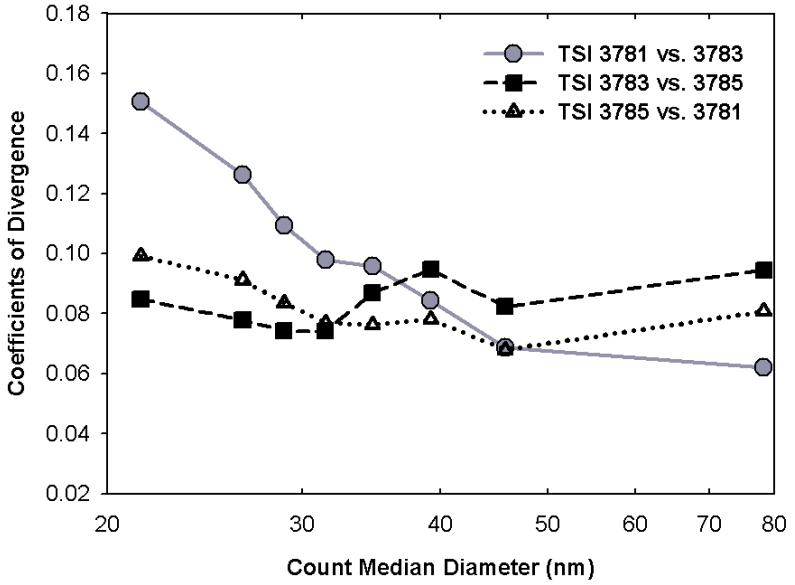
Inter-model Correlations (Bias)

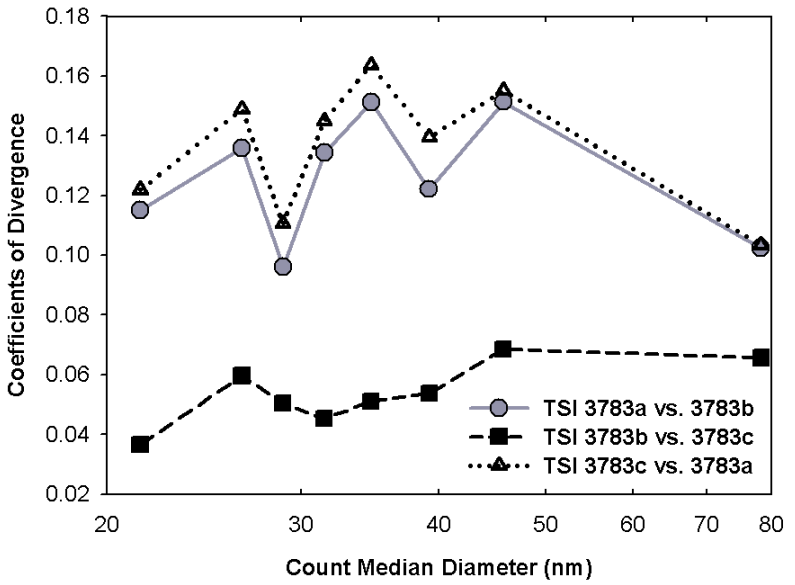


Size Distribution









Conclusions

- Intra-model variability was small but not negligible

- Intra- and inter-model correlations worsened under downwind conditions (i.e. elevated particle number levels) and improved with increasing averaging time

- Model 3781 recorded the lowest number concentrations (particles with CMD < 45 nm were underestimated)

- Model 3783 recorded the highest number concentrations, especially under downwind conditions

- Model 3783 (designed for long-term monitoring) provided relatively consistent data over one-month

- A long-term evaluation of model 3783 is underway